L2: Entry 18 of 46 File: USPT Jun 9, 1992

DOCUMENT-IDENTIFIER: US 5119555 A
TITLE: Non-explosive separation device

BSPR:
This invention relates to separation devices of the type used to fasten, retain or latch together components of apparatus or structure which are to be separated or released under controlled conditions. In particular, the invention relates to a non-explosive separation device for applications such as providing a safe and reliable replacement for explosion-actuated fasteners or explosive bolts.

BSPR:
Explosion-actuated separation devices such as explosive bolts have been used in a wide variety of applications in which components or parts of a device or structure are secured together for quick separation when the explosive device is activated. Explosive bolts of this type have been utilized for the deployment of payloads of space vehicles, for the safing and arming of ordnance and for the release of emergency hatches. They have also found application for the underwater release of elements, for example oceanographic equipment or for the recovery of instrument packages from torpedoes used in target practice.

BSPR:
While the explosive bolt technology has been developed to a high degree, their use for many applications presents a number of problems and limitations. When explosive bolts are actuated the resulting mechanical shock can cause unintended damage to associated structures, such as protective shrouds and fairings, and to equipment, for example to the electronics in payloads or to instrument packages of the components being separated. The explosion devices are also relatively sensitive such that they are hazardous to store and use. When actuated shrapnel from the explosive devices can cause injury to personnel and damage to surrounding equipment.

BSPR:
Another disadvantage from existing explosion-actuated separation devices is that there is no reliable non-destructive method for testing the integrity of the separation device in a stand-by mode. Furthermore, the deflagrating charges employed in such explosion-actuated devices are subject to deterioration over time with the result that they do not have a long shelf life. Explosive bolts are also relatively difficult to install in that special tools and trained personnel are normally required for safely installing and wiring the devices.

BSPR:
Among the prior art separation devices is the mechanism described in U.S. Pat. No. 3,454,286 which employs a fusible material that melts upon heating from ignition of a combustible material to release the elements that are being held together. While such a device is relatively safer in operation as compared to explosive bolts, it also presents a number of disadvantages and limitations such as limited shelf life of the combustible material and the limitations on testing of the actuating circuit and predicting the precise release point of the device.

BSPR:
A further prior art releasable latch mechanism is disclosed in U.S. Pat. No. 3,546,996 where a rise in temperature arms the device through a differential in thermal expansion of two elements. A subsequent drop in temperature causes thermal contraction of the elements back to ambient which ruptures one of the elements to release the latch. Such a mechanism also presents a number of disadvantages and limitations. Operation of the mechanism is dependent upon the

relatively low coefficient of thermal expansion of the metal elements. This requires a large temperature excursion, and consequently a relatively long time period, to build up the requisite tension forces. Additionally, such a mechanism has poor operating sensitivity with the result that it is difficult to predict and control the point in the thermal cycle where the rupture will occur. Consequently such latch mechanisms have only a limited scope of application and generally are not adaptable as replacements for explosive bolts of the type now in use.

BSPR:
Another object is to provide a separation device of the type described in which the shape-memory alloy actuator can be operated an indefinite number of times so that the separation device is reusable upon replacement of the retaining element.

DEPR:
FIG. 2 illustrates another embodiment providing a non-explosive separation device 42 for releasably fastening together components 43, 44 of buoyant oceanographic equipment which is to be released from an underwater location by remote control. Device 42 is comprised of a retaining element 45 in the form of a headless bolt having a shank 46 which extends through aligned openings 48, 49 formed in the two components which are to be separated. The proximal end 50 of the shank projects beyond the outer surface of component 43. A transverse bore 52 is drilled diametrically through the shank proximal end and a shear pin 54, which is the strain concentrated portion, is inserted through this opening with the pin's free ends 56 bent back to lock the pin in place.

DEPR:
From the foregoing it is seen that there has been provided an improved non-explosive separation device which obviates many of the disadvantages and limitations of previously-proposed devices of this type. The separation devices of the present invention are highly reliable and relatively more safe than the type of explosive bolts which are presently in use. Upon actuation of the shape-memory alloy material the retaining element is cleanly severed into exactly two fragments. This has a number of important advantages, including being safer for personnel and surrounding equipment as compared to explosive bolts which are shattered into many small fragments that are driven off in many directions in the form of shrapnel. The invention obviates the problem of mechanical shock and flying shrapnel that can occur from an explosion-actuated separation device.

DEPR:
The separation device of the present invention is also reusable in that it is only necessary to replace the retaining element following each actuation. The shape-memory actuating element can be operated an indefinite number of times, whereas in an explosive separation device the actuating element, which is the deflagrating charge, can operate only once.

DEPR:
Activation of the separation devices of this invention is by heating, such as by electrical current or exothermic chemical process, which is gradual and does not involve a deflagrating charge as in an explosive bolt. In this invention a minimum energy is liberated at the time of separation. The amount of energy required to activate the shape-memory alloy material is a small fraction, on the order of substantially 1%, of that liberated in an explosion actuated separation device. This amount of energy is a difference in kind rather than degree. In the invention the actuation is not immediate or sudden, but takes place over a relatively long time span on the order of several seconds, as compared to an explosion actuated device where the time span of energy release upon the explosion is on the order of only a millisecond. This relatively much lower amount of energy released over a relatively much longer time span is an important consideration in the safety of the device. For example, the separation device of the invention can even be held in a person's hand during actuation without danger.

DEPR:
In the embodiment in which the shape memory material is activated by resistance heating it is a distinctive feature that the energy of activation is stored external to the device and is supplied to the shape-memory alloy element only at the time of activation. This is an inherently safer, cheaper and more reliable

mode of operation than with explosive bolts where the energy of activation is stored in the deflagrating charge within the bolt.

DEPR:
The separation device of the invention is insensitive to transient electrical signals, which could cause accidental triggering in an explosive bolt or other device in which the energy is stored internally in a deflagrating charge.